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PLANTS AND ANIMALS OF MOUNT MARCY, NEW YORK, PART III

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V. Tree Distribution and Exposure

Above timber line[36] in the shelter of certain rocks are found compact groups of stunted balsam firs, while beside others is alpine vegetation. What is it that permits dwarf trees to become established in certain places and not in others?

In the Selkirk mountains of British Columbia Shaw[37] found that timber was lacking in the depressions above approximately 6,000 feet, but extended above this elevation on knolls and ridges. He explains this as due to late melting snows and black fungus which is left on the trees after the snow. It has also been shown by Cowles that in a number of places in North America snow beds and timber line are causally related. Bouget[38] working in the Pyrenees found mesophytic herbaceous communities of mixed lowland and alpine plants where the snow lies late, and trees on the ridges at the same elevations. Thus timber line in the Pyrenees, as in the Selkirks, runs higher on the ridges than in the depressions. Examples of lowland communities where the snow lies late on Mt. Marcy are described above in Part II under the "Dwarf Birch Meadow" and "Meadow on Southeastern Side of the Mountain at 5,100 feet" (Ecology, Vol. 1, No. 3 pp. 220–226). Aside from these two examples, conditions on Mt. Marcy appear to be the reverse of those found in the Selkirks and in the Pyrenees, for on Marcy the trees push upward in the ravines, not on the knolls and ridges. But on Mt. Marcy there are no extensive slopes above timber line to collect snow, whereas in the Selkirks and Pyrenees masses of snow probably come down from above into the ravines, preventing the development of trees by avalanches and by occupying the ground late in the growing season. Hence on Mt. Marcy the trees extend to higher elevations in the ravines than elsewhere.

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[36] See definition of timber line as used in this study, Ecology, Vol. I, No. 2, p. 72.

[37] Shaw, C. H. "Causes of Timber Line on Mountains," Plant World, Vol. 12, No. 8, pp. 169–181, 1909. "Vegetation and Altitude," Am. Naturalist, Vol. 43, pp. 420–431, 1909.

[38] Bougert, J. "De l'influence des neiges sur la repartition des differents végétaux a même altitude dans les zones elevees des Pyrenees," Rev. Gen. Bot. 30: 305–320, 1918, Bot. Gaz. 69: 533, 1920.

It has been supposed that the stunting of trees in arctic regions and on Mountains is due to the winds withdrawing moisture from the needles at times when the frozen ground prevents the roots from replacing this moisture. But recent work on the transpiration of conifers in winter has shown that "the winter transpiration losses from conifers are scarcely greater than those from the defoliated stems of broad-leaf trees."[39] It therefore appears that the winter winds may not be the only cause affecting tree distribution on mountains.

In considering the influence of wind on tree distribution in the alpine zone it is necessary first of all to know something of the winds to which the open places and the groups of stunted trees are exposed. Would not the direction of the shelter with relation to the wind play some part in permitting or preventing tree growth? Information on this question might throw light on the relation of wind to timber line. On Mount Marcy the prevailing winds are from the northwest and the west.

A map (fig. 21) of a portion of the summit above timber line was made by means of a rough plane table, compass and tape. The last was used only between stations, the size of the tree groups, open areas (alpine vegetation), and rock masses, being obtained by pacing. The direction of the winds to which each area is exposed was noted and recorded on the map by arrows. The survey was run along the 5,000 foot contour, starting at a point on the south trail where a metal plug marked "O 107" was found set in a rock dome. The point is marked ".07" instead of "O 107" in the lower part of the map (see fig. 21) where the contour makes a bend at right angles from a north-south to an easterly direction. (Figure 2 in Part I (Ecology, Vol. 1, No. 2, p. 74) was taken at approximately the point ".07," looking north. The main map shows south, west, and northwest exposures; the small insert map gives a typical case of north, northeast and east exposures. In addition to showing exposure to wind the map gives a general idea of the relative proportions of dwarf trees, alpine vegetation (marked "open grasslands" on the map), and bare rock in the lower part of the alpine zone. The proportion of dwarf trees is less above 5,000 feet. Collections of animals, listed further on, were made along the survey line.

In general, the degree of shelter required against south, southwest, and west winds is less than that required against northwest winds. The insert may indicates that easterly winds are also of lesser importance. It will be noticed that on the map a large proportion of the open areas are exposed to the northwest winds, while not a single tree group shows exposure to winds from this direction. On the north side of the mountain, however, not included in the map, is a large body of stunted balsam firs extending well above timber line and exposed on the northwest. But these trees occur in deep, moist ravines almost certainly filled with snow in winter.

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[39] Weaver, J., and Mogensen, A. "Relative Transpiration of Coniferous and Broad-leaved Trees in Autumn and Winter," Bot. Gaz. 68: 393-424, 1919.

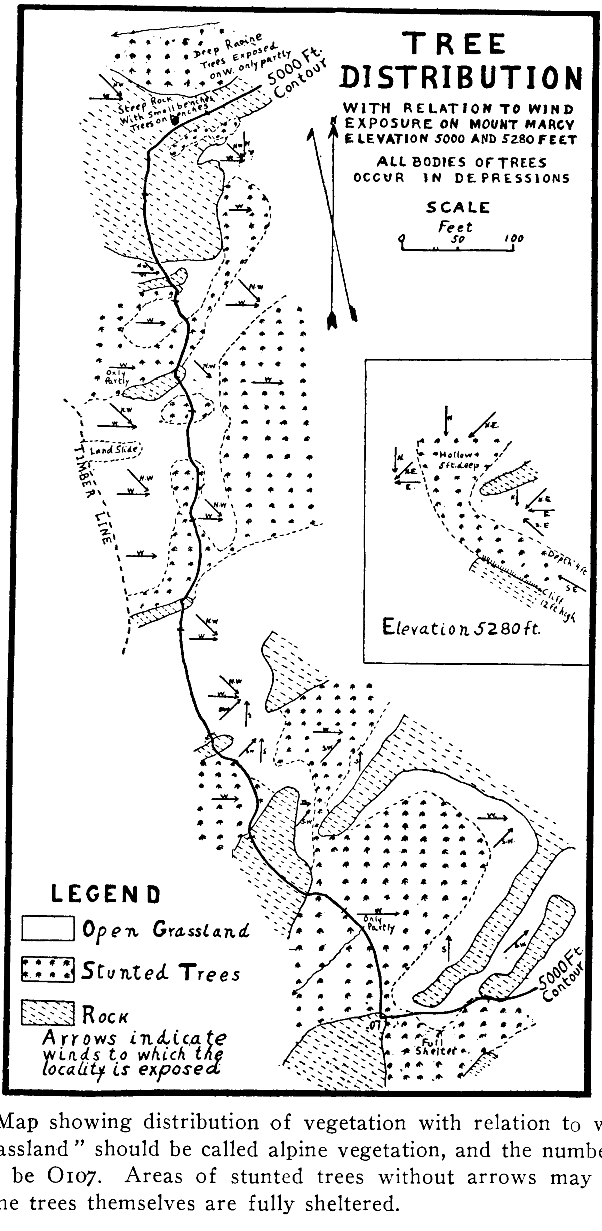
TREE DISTRIBUTION
WITH RELATION TO WIND EXPOSURE ON MOUNT MARCY
ELEVATION 5000 AND 5280 FEET
ALL BODIES OF TREES OCCUR IN DEPRESSIONS
SCALE
Feet
0 50 100
Deep Ravine Trees Exposed on W. only partly
5000 Ft. Contour
Steep Rock With small benches Trees on benches
Only Partly
Land Slide
TIMBER LINE
Hollow 5ft. deep
Depth 4ft
Cliff 12ft. high
Elevation 5280 ft.
Only Partly
.07
Full Shelter
5000 Ft. Contour
LEGEND
Open Grassland
Stunted Trees
Rock
Arrows indicate winds to which the locality is exposed

FIG. 21. Map showing distribution of vegetation with relation to wind exposure. The "open grassland" should be called alpine vegetation, and the number .07 near the bottom should be O107. Areas of stunted trees without arrows may have the tops exposed, but the trees themselves are fully sheltered.

The most striking fact noted during the mapping was that the trees are confined to the depressions.

The only exception, which tends to emphasize rather than to refute the rule, is an occasional flattened black spruce, *Picea mariana,* and balsam fir, *Abies balsamea,* hugging the ground in an opening. These prostrate trees, though not uncommon are by no means abundant, and illustrate in a striking manner the extreme precariousness of tree life outside of the depressions. As a general rule the height of the trees corresponds with the depth of the depression. The trees form a dense and uniform crown canopy at a certain level. Above this uniform canopy the leaders protrude. Only a few are uninjured, many of them are dead, and others are dead on one side. These leaders bear witness to the desperate struggle between the trees and the elements. The trees unceasingly endeavor to extend upward, the elements as steadily kill them back to a certain level. The injury to the partly killed leaders is on the northwest side in the majority of cases. Leaders fully exposed to the north, northeast and northwest winds invariably showed injury on the northwest. Trees on a southerly aspect (S. 22° W. to be exact) showed some injury from the west, a little from the south, but most from the northwest which must be due to the high winter winds sweeping around the mountain. This shows the power of the northwest wind.

Just how the wind acts upon the growth of the trees could not be definitely ascertained. It may be that the canopy level represents a line below which the force of the wind is so lessened by the configuration of the ground that the trees are not injured. Or it may be, and this seems more probable, that the canopy level corresponds with the depth of the snow in winter; the leaders extending above the snow being injured and eventually killed. Variation from year to year in the depth of the snow above a certain level represented by the tree canopy would account for some of the leaders being still uninjured. The nature of the injury does not seem to indicate a high degree of mechanical or "sand blast" action which would come from particles of ice driven with great force. There is none of the etching out of the wood such as is found on the high mountains of the west. Undoubtedly much of the injury is due to mechanical action of a less intense form, but some of it may also be due to drying out by the sun and wind above the snow.

From the area of stunted trees shown at the base of the map (fig. 21) and along its margin were taken the spider *Pardosa musicola* Em., the lady bird beetle *Coccinella transversoguttata* Fab., the leaf hopper or jassid *Oncopsis fitchi* VanD., the alpine wingless grasshopper *Podisma glacialis glacialis Scudd.,* and the grasshopper *Melanoplus atlanis* Riley. Along the survey line, about 400 feet to the northwest in an open grassy area was taken the spider *Pardosa musicola* Em., the grasshopper *Camnula pellucida* Scudd., and *Melanoplus atlanis* Riley, the fly *Bibio longipes* Leow., and the ant *Formica sanguinea* Latr., subsp. *aserva* Forel. At about 425 feet northwest of the starting point was a deep crevice in the rock, facing west and with dripping wet sides. Near this crevice was an area of sedges, *Vaccinium* and *Cladonia,* with prostrate black spruce, and about a foot of sand and humus soil. Here was taken the spider *Pardosa musicola* Em., the grasshoppers *Melanoplus atlanis* Riley, and *Circotettix verruculatus* Kby., the bug *Lygrocoris diffusis* Uhl., the fly *Bibio xanthopus* Wied., and the ant *Camponotus herculeanus* L., subsp. *ligniperda* Latr., var. *noveboracensis* Fitch. At about 900 feet along the survey line a large ravine is encountered. The general character of this area is shown in figure 3, Part I, p. 75. The collections from the vicinity included the spider *Pardosa distincta* Black., *Lycosa albohastata* Em., the grasshopper *Melanoplus atlanis* Riley, a bug *Nabis subcoleopterous* Kby., a caterpillar, an ichmeumon *Amblyteles funestus* (Cress.), a muscid fly *Pollenia rudis* Fab. (infested with a fungus), the fly *Bibio xanthopus* Wied., and the ant *Formica sanguinea* Latr., subsp. *aserva* Forel. The only specimens of the large grasshopper *Circotettix* were taken along this line. They show a preference for bare rock, as in the specimens taken at the beginning of this survey line, when their hovering flight was observed. The fly *Pollenia* is reported as a parasite on earthworms.

VI. Influence of Altitude on Tree Growth

The Mount Marcy region is particularly favorable for studying the influence of altitude on tree growth because one tree species, balsam fir, is found from the lower elevations almost to the summit. Since, however, this study is concerned primarily with timber line and the habitats just above and below it, the records of tree growth were taken at the following points: (1) The lower limit of the pure fir forest, 4,250 feet; (2) at timber line, 4,890 feet, on the extreme upper edge of the continuous forest just below the alpine vegetation; and (3) in the tree groups above timber line at 4,980 feet, with a few at 5,000 and at 5,200 feet.

The growth figures were obtained by means of a Swedish increment borer twelve inches in length. With such small trees it was possible to take cores clear through from one side of the tree to the other. This enabled correction to be made for trees in which the rings were wider on one side of the trunk than the other. The boring did not always strike the centre, but this made no difference since care was taken not to include measurements which were off the radius. It was not practicable to secure figures on total age, nor are such figures essential in determining the rate of growth. Most measurements were taken at a height of twenty centimeters above the ground, the lowest point at which the increment borer can readily be manipulated. In some cases the measurements were taken at thirty centimeters, in exceptional cases higher. Since the total age was not secured the height of the core was of importance chiefly in avoiding the butt swelling. Only dominant trees were taken. The width, in millimeters, of each ten years was measured in accordance with the usual forestry practice.

The accompanying curves (fig. 22) show graphically the rate of growth

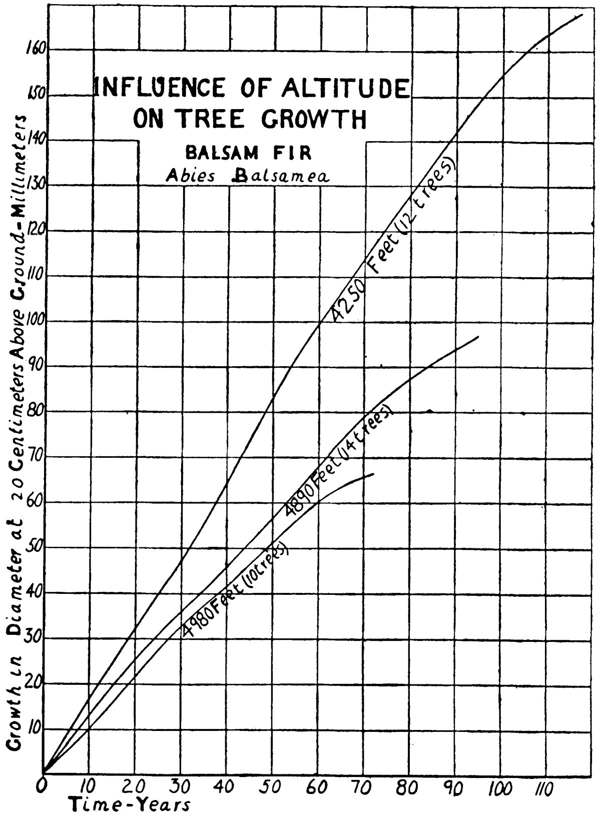

FIG. 22. Rate of growth in diameter inside bark of balsam fir at different altitudes on Mt. Marcy.

in diameter inside bark of balsam fir at the different elevations. These curves were constructed by the usual forestry method, plotting the points for each decade, and averaging these points. A remarkable feature was the regularity with which the curves passed through the average points, it being unnecessary, except in minor cases, to "smooth off" the curves by ignoring points out of line.

Table 5 gives the diameter inside bark at each ten year period, taken from the curves, and also the average annual growth for each decade. It will be noticed that the rate is not uniform throughout the life of the tree. Table 6 gives the age at each centimeter of diameter inside bark, taken from the curves.

TABLE 5. *Growth of balsam fir in diameter inside bark at different altitudes*

Time, Years	Diameter inside bark at each 10 year period, millimeters			Average annual growth in each 10 year period, millimeters		
	At 4,250 ft. elevation	At 4,890 ft. elevation	At 4,980 ft. elevation	At 4,250 ft. elevation	At 4,890 ft. elevation	At 4,980 ft. elevation
10.....	16.8	13	10	1.7	1.3	1.0
20.....	32	25.3	21.5	1.5	1.2	1.2
30.....	47	36	32.7	1.5	1.1	1.1
40.....	64	45.7	41.5	1.7	1.0	.9
50.....	83	56.6	51.2	1.9	1.1	.9
60.....	99.5	68	60.3	1.6	1.1	.9
70.....	114	79	65.7	1.5	1.1	.6
80.....	128	87.4		1.4	.8	
90.....	142	94		1.4	.7	
100.....	154.8			1.3		
110.....	164			.9		

TABLE 6. *Age of balsam fir at each centimeter of diameter inside bark at different altitudes*

Centimeter inside bark	Age, years		
	At 4,250 ft. elevation	At 4,890 ft. elevation	At 4,890 ft. elevation
1................	6	8	10
2................	12	16	19
3................	19	24	28
4................	25	34	38
5................	32	44	49
6................	38	53	60
7................	43	62	
8................	48	71	
9................	54	84	
10................	60		
11................	67		
12................	74		
13................	81		
14................	89		
15................	96		
16................	105		

The decrease in rate of growth is not in exact ratio with increasing altitude. The average annual growth for the first 60 years at each of the three elevations represented in the curves is as follows:

At 4,250 feet, average annual growth of first 60 years	1.65 mm.
At 4,890 feet, average annual growth of first 60 years	1.13 mm.
At 4,980 feet, average annual growth of first 60 years	1.01 mm.

Plotting these values we find that the decrease per unit of elevation is greater between 4,890 and 4,980 feet than between 4,250 and 4,890. It appears therefore that rate of growth diminishes with altitude, and that at a certain point (the beginning of alpine vegetation in this case) the diminution per unit of elevation becomes more rapid.

The curves show that the influence of altitude is exerted not only upon the rate of growth, but upon the longevity of the trees. It will be noticed that at 4,980 feet the growth rate drops off at 60 years. At timber line the rate continues for 70 years (68 to be exact), while at 4,250 the final drop in rate does not occur before 95 years, although there is a decrease after 50 years. Thus, at the higher elevations the trees not only grow more slowly but are shorter lived; on the other hand, decay seems to be more prevalent below timber line.

VII. GROWTH FORMS OF PLANTS

In considering the response of the vegetation above timber-line, it seems best to omit from our calculations several species credited to the region and either so rare or actually wanting now that they are scarcely of significance. The omitted species, for the purposes of sorting into the Raunkiær growth-form categories, are *Juniperus communis, Carex vitilis, Carex concolor, Epilobium angustifolium, Kalmia glauca, Melampyrum latifolium, Rhinanthus crista-galli* and some others. This leaves 60 species which certainly make up 99 percent. of the vegetation above timber line.

In sorting these into the Raunkiær[40] growth-form categories all woody plants, because of their dwarf habit, have been classed as nanophanerophytes, except those that would naturally go in with the chamaephytes. It may be objected that the fir, black spruce, paper birch, and *Sorbus scopulina* are trees and should consequently go in categories calling for greater stature than nanophanerophytes. The best answer to this is that on the open summit outside of sheltered depressions they are never over 3 feet, and usually flattened against the ground. The flora above timber line, so far as the growth forms are concerned appears to be separable as follows:

Nanophanerophytes	13	or	21.66 percent.
Chamaephytes	9	or	15 percent.
Hemicryptophytes	29	or	48.33 percent.
Geophytes	9	or	15 percent.

As these figures and percentages are of value only in comparison with other regions, and only thus do they indicate response of plants to varying environments, the following table is submitted.

It will be seen from this that the vegetation on the top of Marcy is much like that on the Labrador Coast or in Spitzbergen, notably in the failure of trees of any height to develop, and in the high percentage of perennial herbs. It would be an interesting study to determine, as one of the authors has done for Long Island, N. Y., how these percentages would be effected by considering individuals rather than species. All that could be considered with the time at our disposal were the species, but a more extended study would no doubt result in changes if only the species which make up the bulk of the flora of the summit, were the ones considered.

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[40] Fuller, G. D., and Bakke, A. L. "Raunkiær's Life-forms, Leaf-size Classes and Statistical Methods." Plant World, Vol. 21, pp. 25–37, 1918.

Smith, W. G. "Raunkiær's Life-forms and Statistical Methods." Jour. Ecol., Vol. 1, pp. 16–26, 1913.

TABLE 7. *Biological spectrum of the flora above timber line on Mt. Marcy, as illustrated by Raunkiær's growth-forms, in percentages. (The normal spectrum, and other regions included for comparison.)*

Type of growth form	MG	MS	MC	N	CH	H	G	HH	T
Normal spectrum	6		17	20	9	27	3	1	13
Flora of vicinity of N. Y.	.52	4.03	7.18	3.51	5.29	33.29	20.23	11.74	13
Flora of vicinity of N. Y. Northern element of it only		1.31	3.94	8.55	8.55	26.31	24.32	23	3.94
400 commonest species on L. I., N. Y.	1.50	3.00	8.50	4.25	7.25	30.00	21.00	6.75	14.25
Baffin's Land				1.00	30.00	51.00	13.00	3.00	2.00
Iceland				2.00	13.00	54.00	10.00	10.00	11.00
Spitzbergen				1.00	22	60.00	13.00	2.00	2.00
Labrador Coast		2.00	1.00	8.00	17.00	52.00	9.00	5.00	6.00
Above timber line on Mt. Marcy, N. Y.				21.66	15.00	48.33	15.00		

The figures given, however, are in line with those from the arctic-alpine regions where the chamaephytes and hemicryptophytes are relatively high in number, In the last five localities of the above table, including the summit of Mt. Marcy, there are practically no trees.

So far as species are concerned, it is not without significance that by leaving out of the count those plants that have come up through the fir forest to the summit, we find the remaining element of the vegetation, which may be considered certainly as alpine or sub-alpine to consist of:

N—6, CH—9, H—14, G—-.

While the element that has come up from below and seems an obvious encroachment into the alpine zone consists of:

N—8, CH—-, H—15, G—9.

No attempt has been made to give growth-form percentages from the station *a* at the 4,250 ft. elevation. If *species* were considered here the fir would only figure as one, while if individuals were reckoned it would show 85 percent. of the forest as fir. In nearly exclusive forests of the sort, the Raunkiær growth-form percentages may obscure, rather than elucidate, the truth about vegetative response to climate, while in the alpine zone they give interesting comparisons with the flora of other parts of the world.

VIII. SUMMARY AND CONCLUSION

The methods of study and viewpoints of zoologists, botanists, and foresters have been brought together for a brief cooperative study of the factors causing the sharp differentiation of habitats at timber line on mountains. Timber line was taken as the end of the continuous forest, except in depressions, and beginning of alpine vegetation; this occurs on Mt. Marcy at approximately 4,900 feet elevation.

Mount Marcy is 5,344 feet high, possessing above timber line a relatively small area of rather uniform relief exposed on all sides. A well-defined cirque was found on the north slope at 5,250 feet.

Geologically the region is one of the oldest mountain areas of the world, mountains being formed and worn down repeatedly. There has been much faulting. Scouring and filling by glacial ice and waters was followed by depression and reelevation.

The rock forming Mount Marcy is a resistant, coarsely crystalline, greenish colored anorthosite resulting from the thrusting of molten masses into overlying sedimentaries including limestone. The rock contains approximately 10 percent. of lime, which, however, is not readily available to plants.

The climatic winter of the summit, if snow be the criterion, commences in the latter part of September or early October and ends in June, giving barely two months of summer. Previously no weather records have been kept on the mountain. Records for five stations 37 miles air line from the summit or nearer, and over 1,000 feet in elevation, give a mean annual temperature of 42.13° F. south of the mountain and 39.54° north of it, with mean maxima of 92° and 95°, and minima of —36° and —28° respectively. The growing season for the region of which Mount Marcy is roughly the centre averages 92 days, as compared with 120 for the Catskills and 200 on Long Island. Precipitation is distributed rather uniformly over the year, and is on the whole high and sporadic.

To determine as far as possible the relative differences in the climatic factors influencing the various habitats, brief instrumental records were secured of evaporation, solar radiation, air temperature and soil temperature at the critical points in the vegetative covering. These points were (*a*) the lower limit of the fir forest at 4,250 feet, which from here up forms a uniform vegetative unit extending to timber line; (*b*) the bog at the east end of Lake Tear (headwater of the Hudson River) at 4,320 feet; (*c*1) the dwarf fir forest just below timber line at 4,890 feet, in the tree crowns; (*c*2) the same as (*c*1), but on the ground under the dense forest; and (*d*) the alpine zone just above timber line at 4,920 feet.

The rate of evaporation tends to increase with elevation, except that the rate in the bog was higher than that just below timber line. The rate under the cover of the dwarf fir forest was lowest of all owing to shelter from sun and wind.

Solar radiation shows a similar relation to altitude. Taking that above timber line as 100 percent, the stations were: (*d*) 100 percent, (*b*) Lake Tear bog, 99 percent, (*c*1) crown of dwarf forest, 89 percent, (*a*) lower limit of fir forest, 51 percent, and (*c*2) under dwarf forest, 4 percent.

The average daily range of air temperature (difference between maximum and minimum) increased with altitude, except that the range just below timber line was a trifle greater than that just above.

Summations of temperature above 40° F. showed that the heat available for growth diminishes with altitude except for the bog. A sharp drop in effective temperature between the station just below and that just above timber line corresponds with the abrupt contact between the two life zones, and suggests that the amount of effective temperature may be a leading factor in causing the sharp line of demarkation at timber line.

Soil temperature at 1½ inches was highest in the bog, and a trifle higher in the alpine zone than at the lower limit of the fir forest. But at a depth of 12 inches the soil temperature appears to decrease with increasing altitude.

Analyses of a limited number of soil samples showed the dry matter to contain from 12.24 to 21.93 percent of organic and volatile substance and from 1.75 to 2.31 percent of nitrogen (save for an exceptional sample which contained only .79 percent of nitrogen). All showed a high lime absorption coefficient, indicating high acidity in spite of the high lime content (10 percent) of the underlying rock.[41]

The fir forest is of nearly uniform composition from 4,250 feet to timber line, being practically pure *Abies bálsamea* with only a small scattering of paper birch, *Betula papyrifera.* The height and diameter of the firs diminishes with altitude from approximately 45 feet high by 8 inches in diameter to 10 feet by 3 inches. Fir reproduction is abundant wherever the canopy is not too dense. The dominant herb of the moss covered forest floor in the lower part of this forest is bunch berry, *Cornus canadensis,* and in the upper part is *Oxalis Acetosella.* Most of the plants of the understory, even up to timber line, are on the whole plants of lower and moderate elevations.

The chief bird habitat is below the area included in this study. In the fir forest juncoes, golden-crowned kinglets and myrtle warblers were the most abundant of the few species seen, though some twenty other kinds of birds have been previously recorded from here. Little evidence of mammal life was seen in the fir forest, aside from deer and red backed and white footed mice, though other mammals have been reported. No amphibians, except a frog at 4,300 feet and toad at 4,500 feet were found, and probably the short summer prevents their living here. In the upper part of the fir forest, where the trees are dwarfed and extend in locally protected depressions above timber line, no mammals were found except the red backed mouse, which seems to be established here, and signs of the varying hare. Several birds were noted.

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[41] Dr. Edgar T. Wherry of the U. S. Bureau of Chemistry has kindly examined a specimen of similar anorthorite from Mt. McIntyre since Part I of this paper was published. He finds that the calcium is combined in the form of silicates which are comparatively insoluble and form the feldspar known as labradorite. There is no evidence that lime is present to any extent as carbonate.

The vegetation of the Lake Tear bog consists of bog plants, *Carex oligosperma* dominant near the lake and *Calamagrostis neglecta* dominant elsewhere, with a few alpines, notably the crowberry *Empetrum nigrum,* and scattered young fir trees at one end. The alpine plants occur only in this bog and above timber line, being absent from the intervening belt of fir forest. The invertebrates collected in the bog were mainly species living in the open rather than in the forest. Of special interest is the grasshopper *Podisma glacialis glacialis,* which like the crowberry, was also found in the alpine zone.

In two meadows well above timber line are found a number of lowland plants, one of them, *Calamagrostis canadensis,* being dominant, and some of them not hitherto recorded from above timber line on Mount Marcy. In these meadows were also collected animals from lower altitudes, showing the encroachment of lowland animals as well as plants into the alpine zone.

Of 73 species reported by Peck from the alpine zone, 21 may have disappeared or at least were not seen by us. Of 7 species not reported by Peck and which apparently have come in since 1879 or later, it is significant that none are true alpines and 4 are certainly encroachments from lower down the mountain. Only 23 species are true alpines, and at least 30 have apparently come up through the timber line from the forest below, dwarfed in stature and changed in color, but still flowering and fruiting. Not one case of invasion from the alpine zone into the fir forest below was found. The evidence of the plants shows that the alpine forms are not spreading downward and may even be vanishing while the lowland forms are pushing upward, indicating that the northward migration which followed the retreat of the ice sheet is still going on.

In studying the relation of wind exposure to stunted trees above timber line a map was made along the 5,000 foot contour showing clumps of stunted trees and open areas, with arrows indicating the direction of the winds to which each locality is exposed. The map indicates that trees require more shelter against northwest winds than against winds from any other direction, and are confined to the depressions. As a rule the height of the trees corresponds with the depth of the depression, and the trees form a very dense canopy at a certain level which probably corresponds with the depth of the snow in winter. The trees continually send up leaders above this level, which are gradually but surely killed back. The injury to leaders above a certain level is generally on the northwest, and does not indicate a high degree of mechanical or "sand blast" action. Collections of animals were made along the survey line of the map from the groups of stunted trees, from the open, and from the bare rock.

The rate of growth in diameter of balsam fir was measured at 4,250 feet, 4,890 feet, and 4,980 feet. Growth decreases with altitude, but not uniformly, the decrease being more marked at timber line. Longevity of the trees also diminishes with altitude.

An analysis of the vegetation above timber line in accordance with Raunkiær's growth-forms permits comparison with the "biological spectrum" of other regions and shows that the vegetation of the top of Mount Marcy is much like that on the Labrador Coast or in Spitzbergen. The "spectrum" of the alpine and sub-alpine element of Mount Marcy shows significant differences from that of the plants which have invaded the summit from below.

One of the most interesting conclusions of this study is that the plants and animals of the alpine region are evidently not spreading downward but that there is a distinct upward extension of the lowland forms. The peak of Marcy forms a small open area (like Lake Tear) in an area of fir forest, the climax forest. This forest tends to take complete possession of all open spaces and it naturally encroaches upon alpine or bog areas. In this we see the intimate relation between local and geographical influences.

Observations and brief instrumental records of climate on Mt. Marcy seem to suggest that the most important factors in causing the timber line on mountains are effective temperatures, wind, and the depth of snow. It is not unlikely that the contrast between the open and the forest vegetation is more important to animals than the change in the physical conditions, although the two can not be wholly separated.

In conclusion we wish to urge the need of both photographic surveys and the detailed mapping of the timber lines on our mountains; and attention should also be given to photographs showing the stages of melting snow.

In working up the collections assistance was generously given by the following who determined specimens submitted to them:

Charles P. Alexander, Illinois State Natural History Survey. Tipulid.
Charles T. Brues, Bussey Institution, Harvard University. Parasitic Hymenoptera.
Nathan Banks, Museum Comparative Zoology, Cambridge, Mass. Phalangids and Psocid.
R. V. Chamberlin, Museum of Comparative Zoology, Cambridge, Mass. Myriopod.
C. J. Drake, The N. Y. State College of Forestry, Syracuse, N. Y. Certain Hemiptera.
J. H. Emerton, Boston, Mass. Spiders.
Charles W. Johnson, Boston Society Natural History, Boston, Mass. Diptera and miscellaneous insects.
A. P. Morse, Wellesley College, Wellesley, Mass. Orthoptera.
Herbert Osborn, Ohio State Univ., Columbus, Ohio. Homoptera.
E. M. Walker, Univ. of Toronto, Can. Aeschnid.

W. M. Wheeler, Bussey Institution, Harvard University, Boston, Mass. Ants.

C. F. Batchelder, Cambridge, Mass. Mammals.

Kenneth K. Mackenzie. Sedges.

Ralph C. Benedict. Ferns.

R. S. Williams. Lichens and mosses.

The soil analyses were kindly made by C. H. Jones, Chemist of the Vermont Agricultural Experiment Station.

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To Dr. C. Stuart Gager, Director of the Brooklyn Botanic Garden at Brooklyn, N. Y.

To J. L. Hills, Director of the Vermont Agricultural Experiment Station, Burlington, Vt.

To Dr. Hugh P. Baker, at the time of this study Dean of The New York State College of Forestry at Syracuse, N. Y., through whom The Roosevelt Wild Life Forest Experiment Station cooperated.

Finally on behalf of the Ecological Society of America, the Chairman of the Committee wishes to take this opportunity of extending the Society's thanks and appreciation to all who have in any way helped in this investigation.

CORRIGENDA FOR PART II

On page 207, 7th line, after (p. 50) add "and there are as well many transient species" The sentence immediately following should read "Since less than 30 species of birds have been found above the hardwood zone (2,500 feet) and since the forests above this level are too dense to attract all but perhaps 15 species (Eaton,[18] p. 42)," . . . The first word in the 14th line should be Some instead of Other. In the 27th line *hudsonitus* should be *hudsonicus*.

On page 209, 12th line, for "the chief source" read "a source."

On page 212, 13th line, "Prine" should be "Prime." The first word in the 13th line from the bottom should be "bellied" instead of "billed."

On page 214, 18th line, "*Ignobalis* Low" should be "*ignobalis* Loew." In the 23d line after the sentence ending "forest humus" insert the following: "*Conotyla* is recorded from under bark, among decaying leaves and other vegetation. Dr. R. V. Chamberlin, in a letter, writes: 'The only reference in literature to *Conotyla fischeri* is in Ann. N. Y. Acad. Sci., 1895, vol. 9, p. 71, the place of the original description. Cook gives the habitat as Central New York, stating that he had about 100 specimens from Onondaga, Wayne and Ontario counties. As to its habits he says, "at Marcellus several individuals were found under the loose bark of a fallen butternut tree (*Juglans cinerea*). All the other specimens were found among leaves and rotting vegetable matter in moist woods." Related species are known from caves (Indiana) and from mountains in the West from where I have described a number of species. I found them to prefer particularly deep, cool canyons in the bottoms of which they were often found in considerable numbers under accumulations of leaves. In general these and other forms of the same family are found in particularly moist situations, being more sensitive to conditions of dryness than most other diplopods. I may add that I have specimens of *Conotyla* taken under leaves in damp woods of Illinois, Minnesota, etc.'"